California Energy Commission
Natural Gas Transportation

Natural Gas Vehicle Technology Forum and ARPA-E 2014 Annual Meeting

Tim Olson, California Energy Commission

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Los Angeles, California

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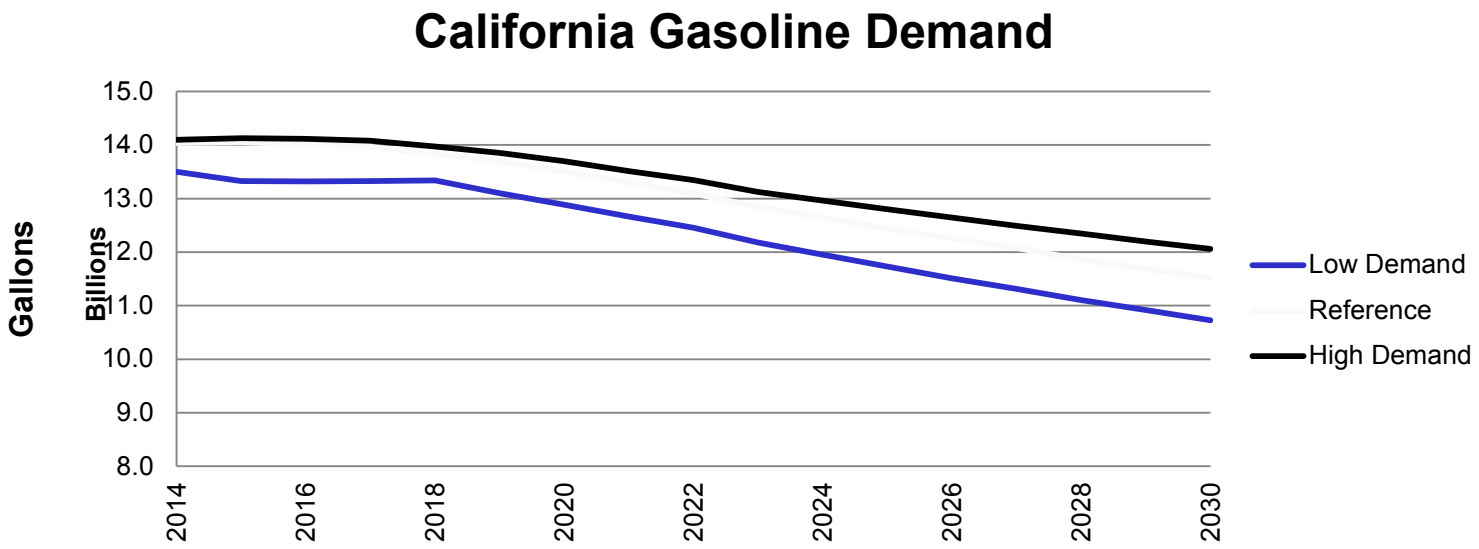
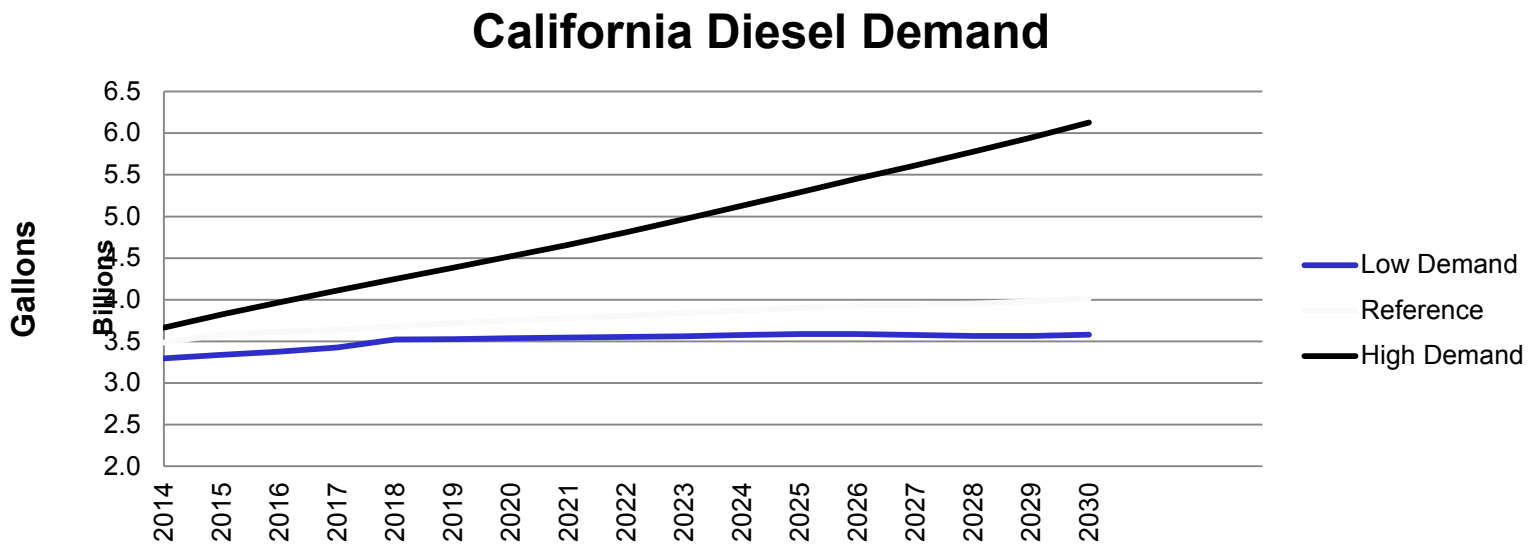
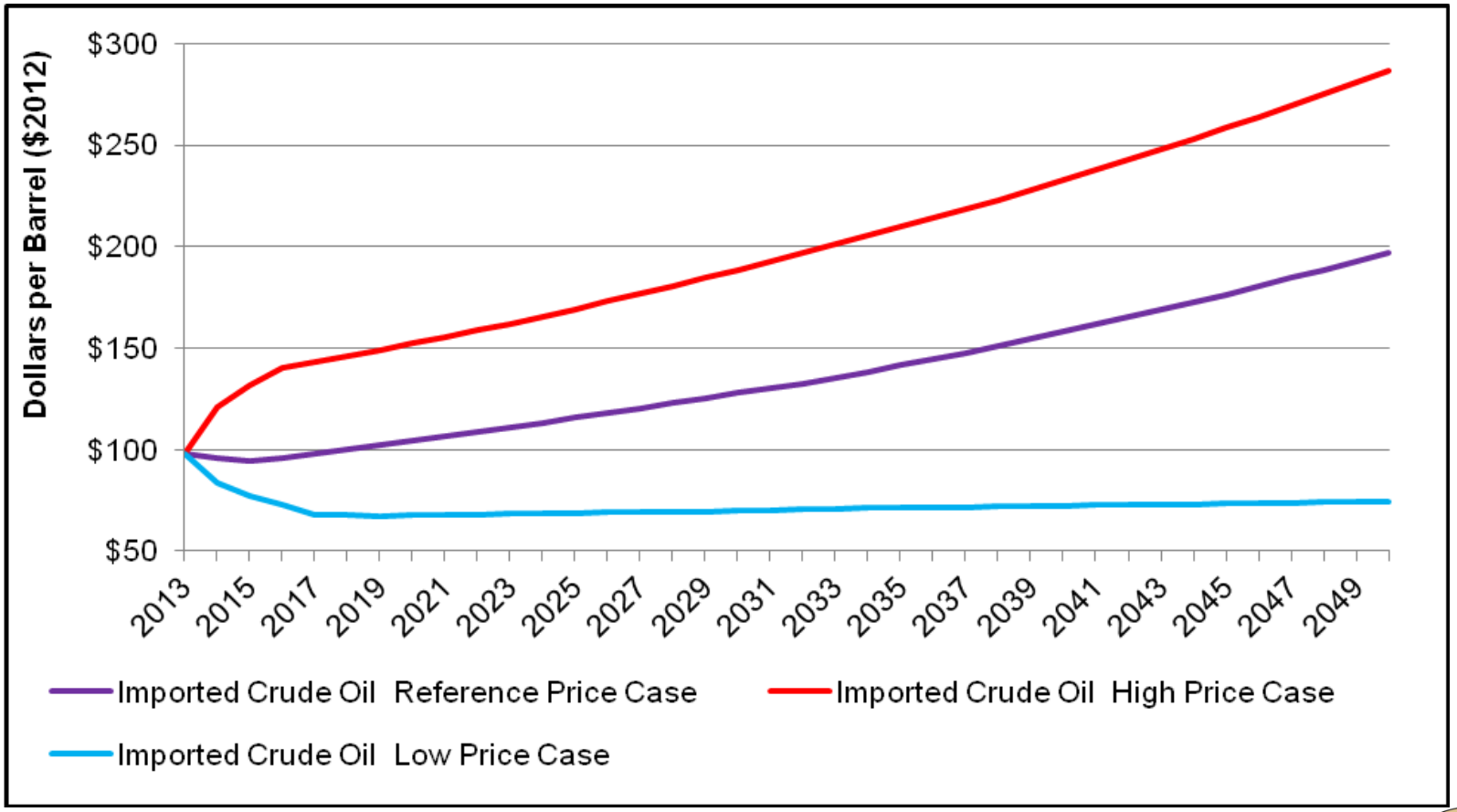
California Energy Commission Transportation Energy Activities

- Integrated Energy Policy Report (IEPR)
  - Transportation Energy Demand Forecast and Supply Scenarios and AB 1257 Natural Gas Opportunities
  - Alternative Fuels Benefits Report
- Research and Development Natural Gas Transportation Program
- AB 118/AB 8 (ARFVT)


California Gasoline Demand
Gallons
Billions
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
2014
2016
2018
2020
2022
2024
2026
2028
2030
Low Demand
Reference
High Demand


California Diesel Demand
Gallons
Billions
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Low Demand
Reference
High Demand

Crude Oil Price Cases



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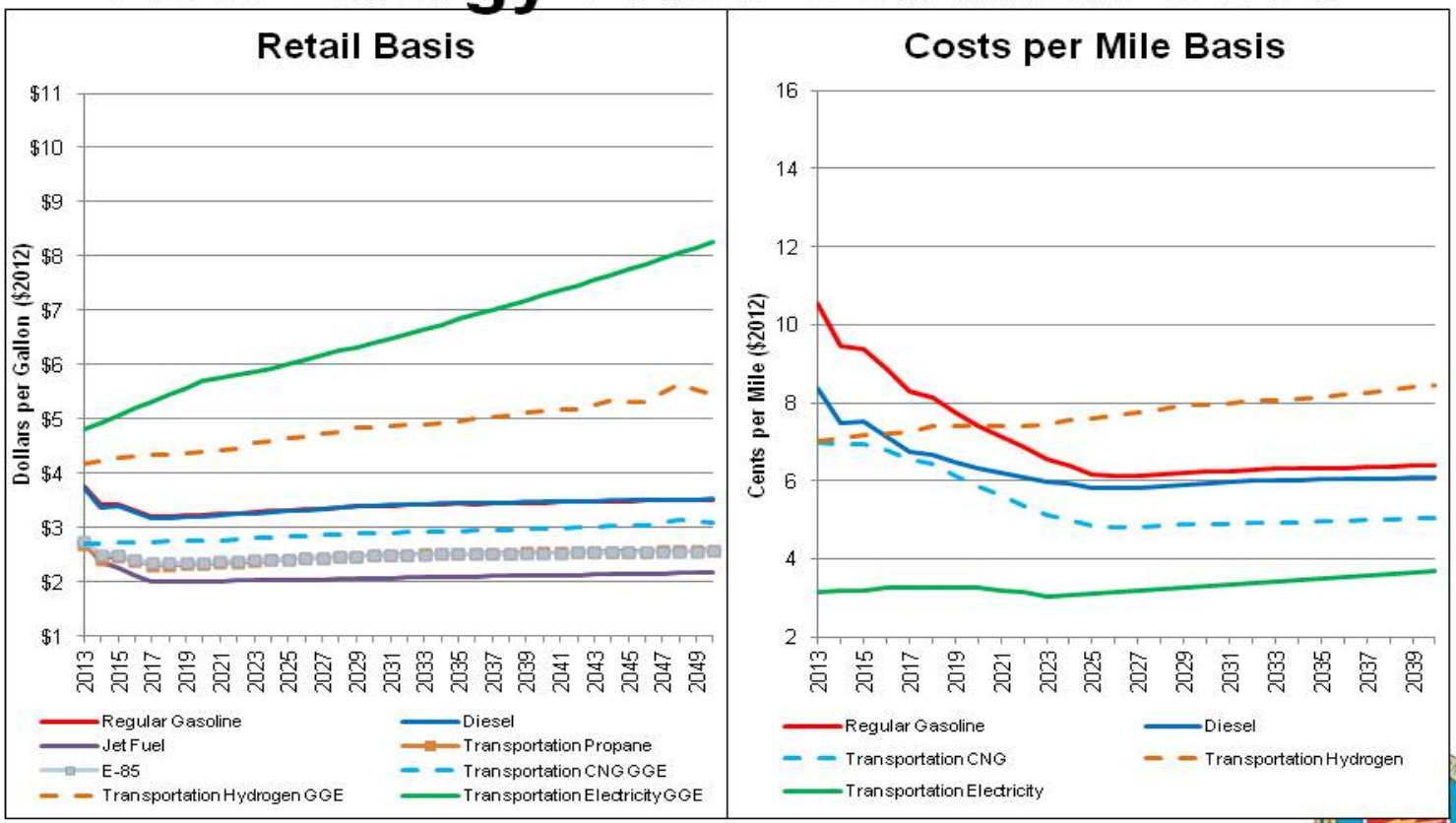
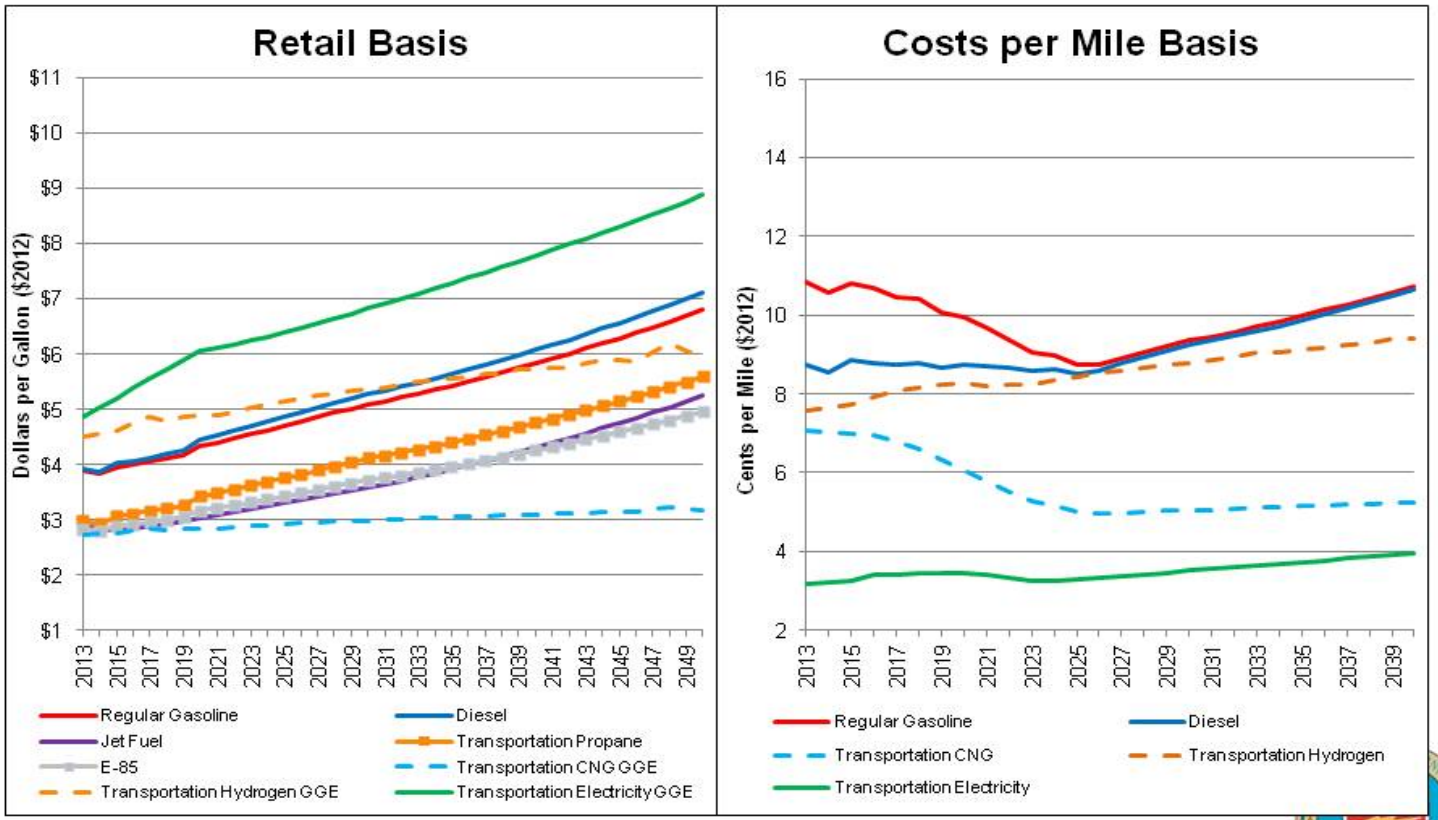
Low Energy Price Common Case



Source: Energy Commission

California Energy Commission

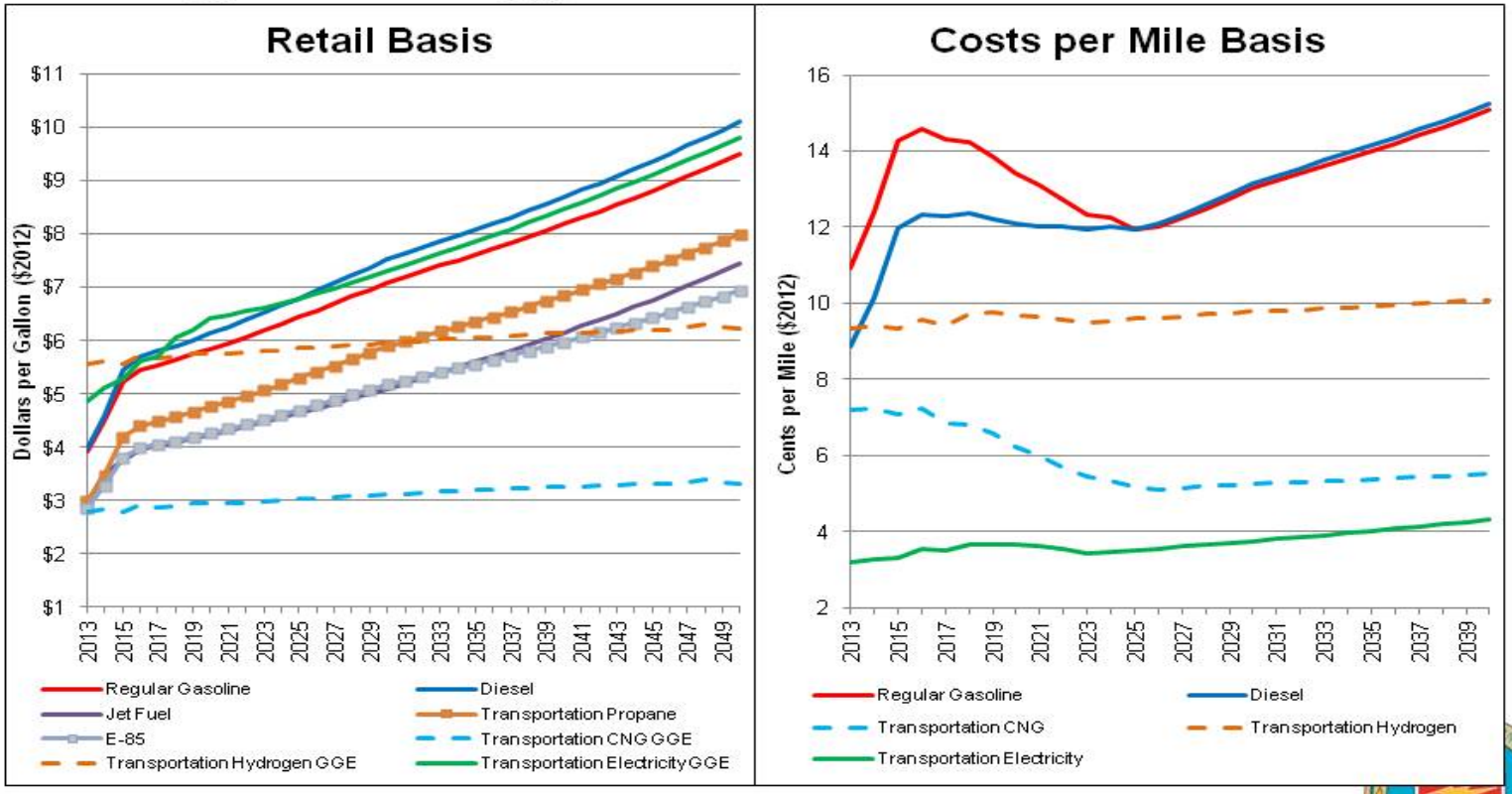
Reference Common Case



Source: Energy Commission

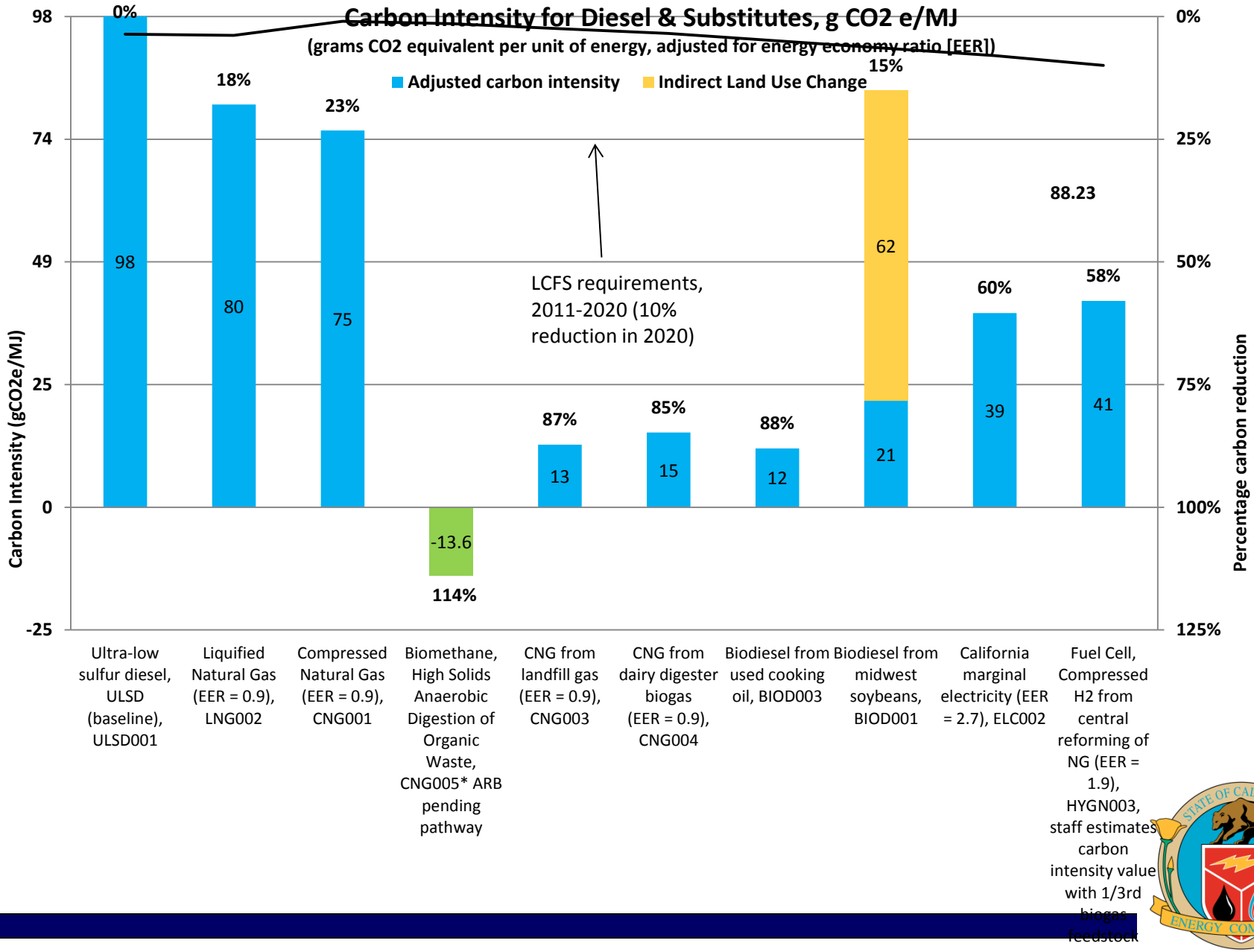
California Energy Commission

High Energy Price Common Case

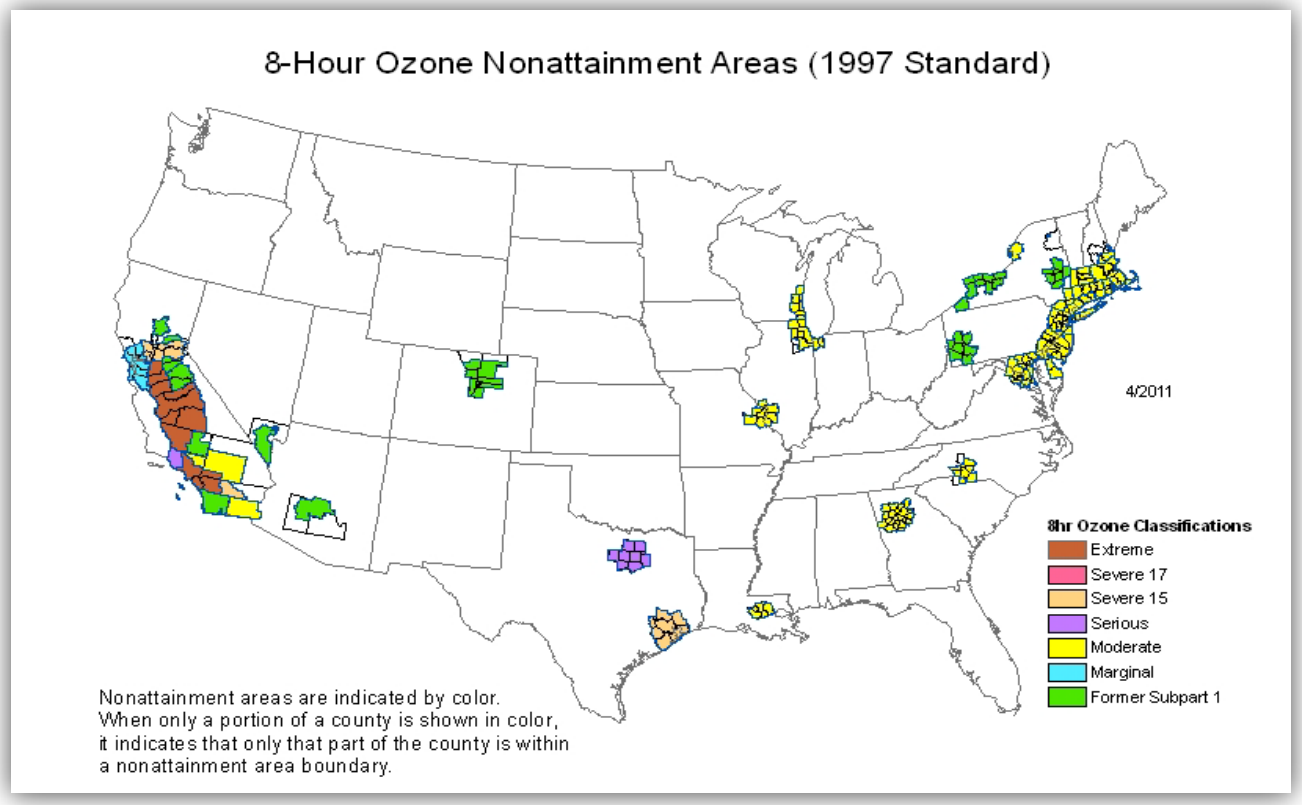


Source: Energy Commission

California's Transportation Energy Initiatives	
Policy/Law/Regulation	Quantified Objectives
Global Warming Act(2006)	Reduce greenhouse gas emissions to 1990 levels by 2020 and 80% below 1990 levels by 2050
Petroleum Reduction and Alternative Fuel Goals (2003) and Alternative Fuels Plan (2007)	Reduce petroleum fuel use to 15% below 2003 levels by 2020. Increase alternative fuel use to 9% of California's fuel consumption by 2012, 11% by 2017, and 26% by 2022
Bioenergy Action Plan (2006)	Produce 20% of biofuels used in California from in-state sources by 2010, 40% by 2020, and 75% by 2050
Low Carbon Fuel Standard (2007)	Reduce carbon intensity of transportation fuels sold in California by 10% by 2020
Zero Emission Vehicle Mandate (2009) and ZEV Executive Order (2012)	Establish goals for automakers to provide electric and hydrogen vehicles for sale in California by 2020 ensure California has infrastructure to support 1 million ZEVs by 2020 and 1.5 million by 2025
AB 118/AB 8, Carl Moyer, and Cap and Trade Incentives (2003, 2005, 2007 and 2013)	Energy Commission, ARB and local air districts provide financial incentives to fund vehicles, infrastructure and fuel production projects that reduce greenhouse gas emissions and air pollutants and increase the use of alternative fuels


Carbon Intensity for Diesel & Substitutes, g CO2 e/MJ
(grams CO2 equivalent per unit of energy, adjusted for energy economy ratio [EER])
Adjusted carbon intensity
Indirect Land Use Change
Carbon Intensity (gCO2e/MJ)
Percentage carbon reduction
98
74
49
25
0
-25
0%
25%
50%
75%
100%
125%
0%
18%
23%
114%
87%
85%
88%
15%
60%
58%
98
80
75
-13.6
13
15
12
21
62
39
41
88.23
LCFS requirements, 2011-2020 (10% reduction in 2020)
Ultra-low sulfur diesel, ULSD (baseline), ULSD001
Liquified Natural Gas (EER = 0.9), LNG002
Compressed Natural Gas (EER = 0.9), CNG001
Biomethane, High Solids Anaerobic Digestion of Organic Waste, CNG005* ARB pending pathway
CNG from landfill gas (EER = 0.9), CNG003
CNG from dairy digester biogas (EER = 0.9), CNG004
Biodiesel from used cooking oil, BIOD003
Biodiesel from midwest soybeans, BIOD001
California marginal electricity (EER = 2.7), ELC002
Fuel Cell, Compressed H2 from central reforming of NG (EER = 1.9), HYGN003, staff estimates carbon intensity value with 1/3rd biogas feedstock

Eighteen of California's fifty -eight counties failed the ozone clean air test in the American Lung Association State of the Air 2011 report



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Alternative Fuels Incentive Funding

Category	Funded Activity	2012-2013*	2013-2014	2014-2015
Alternative Fuel Production	Biofuel Production and Supply	$18.0	$23.0	$20.0
Alternative Fuel Infrastructure	Electric Charging Infrastructure	$6.8	$7.0	$15.0
	Hydrogen Fueling Infrastructure	$9.9	$20.0	$20.0
	E85 Fueling Infrastructure	$1.4	-	-
	Natural Gas Fueling Infrastructure	$1.4	$1.5	$1.5
Alternative Fuel and Advanced Technology Vehicles	Natural Gas Vehicle Incentives	$10.8	$12.0	$10.0
	Propane Vehicle Incentives	$0.8	-	-
	Light-Duty Electric Vehicle Deployment	$12.5	$5.0	$5.0
	Medium- and Heavy-Duty Advanced Vehicle Technology Demonstration	$5.4	$15.0	$15.0
Emerging Opportunities	Emerging Opportunities	$2.5	$4.0	$6.0
Manufacturing	Manufacturing Facilities, Equipment, and Working Capital	$14.7	$5.0	$5.0
Workforce Agreements	Workforce Training and Development Agreements	$1.2	$2.0	$2.5
Market and Program Development	Regional Alternative Fuel Readiness and Planning	$2.1	$3.5	-
	Centers for Alternative Fuels and Advanced Vehicle Technology	$2.7	$2.0	-
Total		$90.0	$100.0	$100.0

*2012-2013 includes the modifications that were approved at the October 2012 Business Meeting.

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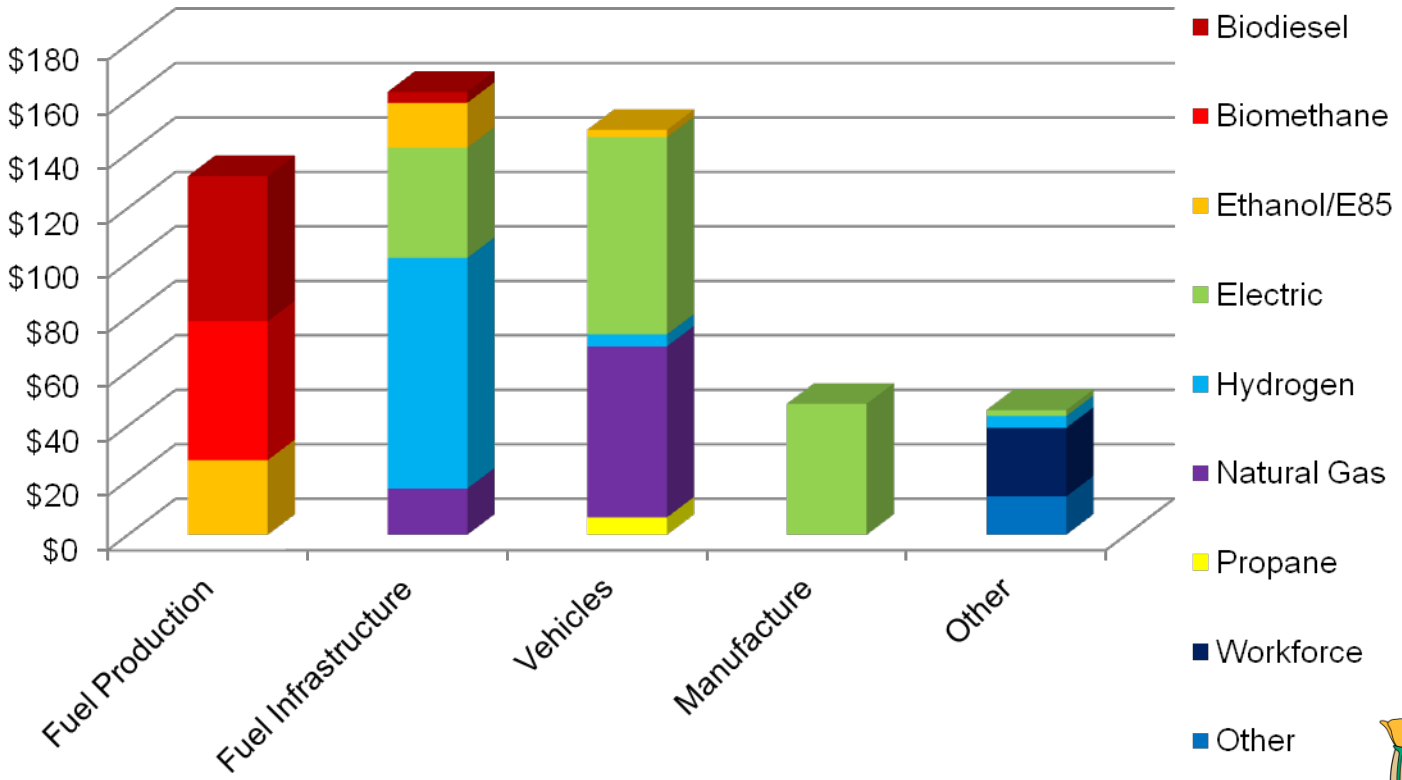
Alternative Fuel Incentive Funding Encumbered



California Alternative Fuel Growth Estimates				
	Fuel Production/Calif. Consumption (Millions of Gallons - GGE and EER Factors)			
Fuel Type	2013	2015	2017	2020
Gasoline Substitutes				
Corn Ethanol Imports	1150	1005	708	593
CA Corn/Grain Sorghum	150	180	220	220
CA Advanced Biofuels	2	63	100	180
CA Sugar Cane/Energy Cane			50	50
Brazilian Sugar Cane Imports	200	250	400	400
Cellulosic	1	5	25	60
Subtotal	1503	1503	1503	1503
Diesel Substitutes				
Palm Oil Imports	0	0	0	0
Soy Imports/CA Production	5	5	5	5
UCO/Corn Oil/Tallow	27	88	150	188
Renewable Diesel	103	157	310	310
Purpose Grown Crops (Camelina, Jatropha)			10	80
Algae			10	100
Cellulosic	1	5	25	60
Subtotal	136	255	510	743
Natural Gas				
CNG/LNG	150	300	500	900
Biomethane		1	2	4
Subtotal	150	301	502	904
Transportation Electric				
Light and Heavy Rail	44	45	45	45
Transit/Trolley	5	5	5	5
PEVs and Hydrogen FCVs	5	40	80	120
Subtotal	54	90	130	170
Propane	20	20	20	20
TOTAL	1863	2169	2665	3340

Natural Gas Transportation Attributes

- Readily Available Fuel
- Fuel Price Advantage Compared to Diesel
  - $1.00 to $1.50/per gallon for 7 – 10 years
- Established Fueling System Network
  - Over 500 Fueling Stations Operating in CA
- Solvent Natural Gas Industry
- Renewable Natural Gas - Low Carbon Fuel Option
- Truck Cost Differential Gap Closing

Overcoming Challenges

- Harmonize Natural Gas Pipeline Quality Standard – CPUC
- Increase Number of Natural Gas Engine and Truck Product Offerings
  - Additional Engine Manufacturers
  - Economy of Scale Manufacturing
  - Improved Truck/Engine Efficiency
  - Vehicle Component Cost Reduction
- Address Methane Fugitive Emissions Leakage
- Increase Government Awareness of Technology Advances and Industry Growth